

having low toxicity, which has an enough bonding strength while ensuring resistance to formation of whiskers, wettability of the solder and so on.

DISCLOSURE OF INVENTION

5 Thus, in order to achieve the objects of the invention, there is provided a bonded structure by a lead-free solder of an Sn-Ag-Bi alloy which is applied to an electrode through an Sn-Bi alloy layer.

10 In the invention bonded structure with utilization of the lead-free solder, the Sn-Bi alloy layer comprises 1 to 20 wt% Bi.

 The invention bonded structure comprises a copper layer between the electrode and the Sn-Bi alloy layer.

15 In the invention bonded structure, the electrode is made of copper material.

 In the invention bonded structure, the electrode is of a lead made of an Fe-Ni alloy or a copper alloy.

20 In the invention bonded structure, the lead-free Sn-Ag-Bi alloy solder comprises Sn as a primary component, 5 to 25 wt% Bi, 1.5 to 3 wt% Ag and up to 1 wt% Cu.

25 The invention is also directed to an electronic article which comprises a first electrode formed on an electronic device and a second electrode formed on a circuit board, the both types of electrodes

being bonded with each other by a solder, wherein an Sn-Bi alloy layer is formed on the first electrode and the solder is made of a lead-free Sn-Ag-Bi alloy.

In the invention electronic article, the Sn-Bi alloy layer comprises 1 to 20 wt% Bi.

The invention electronic article comprises a copper layer between the first electrode and the Sn-Bi alloy layer.

In the invention electronic article, the first electrode is made of copper material.

In the invention electronic article, the electrode is of a lead made of an Fe-Ni alloy or a copper alloy.

In the invention electronic article, the lead-free Sn-Ag-Bi alloy solder comprises Sn as a primary component, 5 to 25 wt% Bi, 1.5 to 3 wt% Ag and up to 1 wt% Cu.

The invention is also directed to a bonded structure by a lead-free solder, which comprises an electrode, wherein the lead-free solder is of an Sn-Ag-Bi alloy comprising Sn as a primary component, 5 to 25 wt% Bi, 1.5 to 3 wt% Ag and up to 1 wt% Cu, which is applied to the electrode.

As can be understood from the above, according to the present invention, it is possible to ensure a stable bonding interface having an enough bonding strength by applying the lead-free Sn-Ag-Bi alloy solder of low toxicity to an electrode such as a

lead frame. With utilization of the lead-free Sn-Ag-Bi alloy solder of low toxicity, it is also possible to ensure a bonding interface which is stable with respect to a change in process of time and which has a high enough strength to withstand stress generated in bonded portions by soldering due to a difference in thermal expansion coefficient between electric devices and a board, a work of dividing the board after soldering, warping of the board during the probing test, handling and so on. Further, with utilization of the lead-free Sn-Ag-Bi alloy solder of low toxicity, it is possible to ensure a bonding interface which has an enough strength and good resistance to occurrence of whiskers by forming sufficient fillets while keeping good wettability at a soldering temperature of, for example, 220-240°C.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 shows a cross-sectional view of a lead for a QFP-LSI according to the invention;

Fig. 2 shows a cross-sectional view of a lead for a TSOP according to the invention;

Fig. 3 schematically shows a testing way of evaluating solder-bonding strength;

Fig. 4 shows evaluation results of fillet strength with regard to various types of metallized leads according to the invention;

Fig. 5 shows evaluation results of wetting